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PASSIVE HEATING, LIGHTING AND COOLING OF A PUBLIC MULTI-USE FACILITY

Prepared for

MONTANA DEPARTMENT of NATURAL RESOURCES and CONSERVATION

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PASSIVE HEATING, LIGHTING AND COOLING OF A PUBLIC MULTI-USE FACILITY

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I. Actual Progress of the Project

This grant project consisting of the construction of the SKC Student Services Center: A multi-use facility composed of three classrooms, a circulation area, a sun space, three offices with reception waiting area and support facilities. The structure incorporates passive solar design to heat, light, and cool the facilities. It also includes earth berming on the north, east, and west sides of the building.

The building also has thermal couple monitoring system in the heat storage walls and maximum/minimum thermometers. All work on the facilities has been completed.

Berming has been completed and landscaping is finished. The monitoring system has been installed and and is functioning. The brochure has been completed and a copy is included in this report.

II. Involvement with the Department

Salish Kootenai College has been in contact with the department's office on several occasions. Our comptroller has contacted the fiscal office for information on fiscal reports. There was one project change, the sod roof, and we were in contact with the project engineer. The department staff was accommodating and helpful. Very early in the project a project engineer did an on-site visit.

III. Publicity

Salish Kootenai College has informed local papers of the facilities existence, to date no feature articles have been run. However, several classes from the local schools have visited the facilities and over 1500 people have utilized or visited the facilities as a function of SKC.

Brochures (see attached) have been completed and are available for visitors.

IV. Expenditures

The attached budget forms cover expenditures of the project.

1. $92,132.00 Funds from SKC
   $40,000.00 Funds from DNRC

2. Costs of materials for the facilities were $81,680.00.

3. Cost of labor for the facility was $54,452.00.

V. Labor

6,806 man hours provided by PATCOR (paid).

1,920 man hours provided by Kicking Horse Job Corps (donated).

8,726 Total man hours

VI. Recommendations

The following recommendations are additional designs and expenditures over and above what would be known as a conventional and sound building structure.

The purpose being to demonstrate that passive heating, cooling, and natural lighting are possible and that the building will still function for the purposes it was intended.

The student services facility is now complete and operating and does verify the fitness of design function.

A. Site Work

The earth berming on the exterior sides of the building has presented no problems with the building. It has greatly increased the ease of heating and cooling. Landscaping and lawns have turned the berms into an esthetically pleasing addition to the building.

B. Concrete and Masonry

The concrete and stone floors and walls are functioning well at storing heat in the winter and cooling in the summer.

The exposed aggregate floors are good in theory but present maintenance problems. They also have presented a problem of moving certain equipment because of the rough texture of the floor.

C. Carpentry

The log beams are esthetically pleasing but do cause some shading of the heat storage floors and walls.

The roof over hang has functioned well for shading windows in the summer.

D. Windows, Doors, and Glass

Heating of the storage walls and floors by the glass is good. The glazed roof over the sun space works very well for heating.

The upper windows in the classroom are not accessible enough and some what impair adequate ventilation for cooling. This should be re-designed for maximum efficiency.

The double door entry works very well for minimizing heat loss at entrance.

Utilizing the sun for solar heat creates some visual problems for persons working in certain areas. It requires some adjustment of seating.

E. Special Equipment

The monitoring equipment has been installed. However, it is proving to be fairly sensitive and has been in the shop late evening after the building was closed for the night. I hope sometime in the future, the sod will be installed.

The thermal window shades are another area where some changes have been made and some problems have come up. Originally we were led to believe that Thermal Technology curtains were available for sloped glazing. When it came down to placing the orders we were told they were not available for sloped applications. We were not able to find another manufacturer of sloped glazing insulated curtains at that time. Since the main problem of the sunspace area where the sloped glazing is located seemed to be one of over heating, Levelor reflective louvered shades were installed instead of a thermal curtain. This alleviated the problem of over heating but greatly increased the use of the wood stove in the sunspace since there is no way to keep the heat in. The increased use of the wood stove, however, has a positive side to it. The sunspace is used as a lounge and gathering area. People sit around the stove and talk much as they did around the pot bellied stove in the country store in the old days. A warm, personal atmosphere has been created which stimulates interaction but gives a peaceful feeling in the middle of things.

Window quilt shades were installed instead of the Thermal Technology shades in the east and west class room areas which reduced the R-Value but increased the flexibility, since individual shades were placed on each window stack. Three problems have come up with the Window Quilt shades. The first, which I feel is a major design flaw, is the larger shades often pull out of their side track which makes for no seal along the side, and poor operation. This has also been a problem with the Window Quilt shades installed in the Salish-Kootenai Housing Authority Office Building. Either a larger roll at the edge of the quilt or a tighter side track is necessary to take care of this problem. Very careful operation helps somewhat. A second problem is that the locking mechanism which keeps the shades at a certain position doesn't work well on the long shades. They tend to come down to a closed position and must be tied up. The third problem is with the small shades on the clearstory windows over the storage areas and entrys of the east and west classrooms. These shades are very difficult to operate because of the way the storage areas protrude into the room, so they are left closed most of the time, which cuts out considerable sunlight. A pulley system needs to be installed which would allow operation of these shade draw cords from the side of the storage area.

On the plus side the Window Quilts are beginning to be used very effectively in the building both to keep the heat in and to limit the intrusion of too much sunlight in the fall when the roof overhang is not as effective as during the summer. The beam and pole extension shading device for the east and west classrooms has never been utilized which would help considerably during the spring, summer and fall. The instructor in the computor classroom has been working with the shades and has several settings for them over the four large windows. By leaving some open more than others and changing the shades as the day progresses, he is able to effectively control the temperature and the lighting in his classroom. He is beginning to sail the ship.

The next area I would like to discuss is the passive daylighting feature of the building. This is a relatively new area of endeavor in the solar field and is still just beginning to be explored. There are several very important lessons to be learned from this design, both positive and negative. Daylighting is a very delicate balance between glare (too much light), and not enough light. Orientation is very important, and the shading factor both inside and out is extremely important, especially in the early morning and late afternoon when the light is marginal.

When the building was first opened, the teacher location was at the end of the east and west classrooms farthest away from the doors - please refer to the floor plan in the proposal. This was the area of the most light and it seemed logical to locate the teaching area there. Complaints of eye strain and glare problems surfaced and the teachers were uncomfortable being in the spotlight (in more ways than one) all the time. The problem was resolved when the teaching area was moved to the other end of the room where there was the least amount of sunlight. The conclusion: when a person is in the sunlight, it is easier on the eyes to look toward an area of less light rather than an area of more light. Glare problems can also be reduced through the use of translucent glass which diffuses the light so it is not directed so intensely. The center classroom has translucent glazing over the heat storage wall - please refer to the building section in the proposal. There has been no problem with glare in the center classroom even toward the rear (south) where the most light is. This class room is oriented so the chairs are facing away from the sun and the instructor is at the north end of the room. This orientation has the light coming over the pupils' shoulders and is much more comfortable, however, this arrangement places the instructor facing the sun. I delt with this potential problem by placing log beams across the room from east to west with the lighting attached to them. I felt that this would break up the sunlight so the instructor would not be fatigued looking into the sun. It worked just fine, in fact it worked too well, which brings us to the next lesson. A little shading goes a long way. I used log beams placed approximately five feet on center as decorative elements, as light fixture hangers and as a way of toning down the impact of direct sunlight. These beams cut down the light. They shade too much, especially in the center classroom where the beams are running east to west. (The beams in the east and west classrooms run north and south). The light level in the center classroom gets progressively less as the north wall is approached. The light is very diffused however.

The shading factor from the exterior is also very important not only for solar heating but also for daylighting. The location of the building in an open area with trees to the east and west limits the light during the marginal times of early morning and late afternoon. It is much more open to the east, so the afternoon shading is the biggest limiting factor. Originally, much more thinning of the trees to the west was to take place. This would hêlp the daylighting and the solar heating especially in the west classroom which is closest to the trees. The selective thinning hasn"t been done yet because the trees serve as a buffer between the college and Highway 93. If a few strategic trees were removed, however, a much greater efficiency could be gained during the late afternoon.

Another area of interest is ventilation. This is a very important part of the thermal design as far as comfort of the people using the building is concerned, especially in the summer. The design relies on natural convection (hot air rising) and the mass of the building to keep temperatures at a comfortable level. The shading of the windows of the east and west classrooms and of the offices is also important. There has been some problem with stuffiness in the center classroom and in the reception area of the offices. The plans called for all the clearstory windows in the center classroom to be operable (openable). During the course of construction, somehow, all the operable windows were installed in the east and west classrooms and all the clearstory windows in the center classroom were fixed glass. This condition could be alleviated by changing at least four of the operable clearstory windows from the east and west classrooms to the center, and visa-versa. There is still a problem of opening and shutting these high windows. Either an easily operated lever opener which can be worked with a stick or a ganged clearstory operator control like Clearline Incorporated Window Control Systems would make the whole operation run more smoothly. As it is, an extension ladder is about the only way a person can operate the clearstory windows.

The plan also calls for an operable skylight to be located in the in the office reception area. This item was left out in the rush to get a roof on the building before winter set in. The addition of an operable skylight would not only eliminate the stuffiness in the reception area, but would provide daylighting to this room which now must rely on electric light.

More efficient operation could also be had by running the fan from the sunspace to the west classroom at all times when there are people in the building. This would more effectively transfer heat from the sunspace to the west classroom.

The last item I would like to discuss is the monitoring system. The system consists of a multi channel thermal recorder made by Falbel Solar Instruments, and a Heliotrope 6 channel digital electronic thermometer model #DE300. The readout unit is located in the sunspace so that passers-by can check out the temperatures of the different sensors. The sensors record the temperature of the north and south sides of the heat storage wall of the sun space, the surface of the north wall of the center classroom, the air temperature of the center classroom, the air temperature of the sunspace and the outside air temperature. The system so far, has not been well utilized. The recorder has broken down twice and was out of tape when I checked. It is interesting to note however, that data recorded between September 1 and October 10, 1982 show a very uniform thermal performance with temperature swings of less than five degrees in the walls and less than 10 degrees in the air temperatures even in the sun space. The outside temperatures ranged from the high thirties to the low nineties.

It would be very difficult to calculate the percent of solar heating that the building is utilizing because of the wood heating and back-up electrical systems. Let it suffice to say that the building is very efficient as compared with standard building types. During a seven month period, October through April of last year, part of the time which the insulated shades were not installed and all of the time they were not well utilized, the building used an average of approximately $100.00 per month total energy bill which included the operation of computers, terminals and considerable office equipment.

The cost per square foot of the building including the free labor at an average of $8.00 per hour is $39.72. This is below the median for commercial building especially when the quality finish and the scale of the project is taken into account.

In conclusion, I would say that this building is an example of good solar design which fits the needs of the client, is very sensitive to the site and micro climate, and does not cost any more than a standard quality structure.

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